Design and Quality Assurance of Premium Airframe Castings

AACE Program IA025
Program Summary

by

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AACE Annual Review
October 23, 2002, Wichita, KS

ABSTRACT

This presentation will review and summarize the research that has been undertaken at Northwestern University to develop a framework for the integrated design and engineering of castings for airframe structures. The program addresses three issues that have historically been problematic in the design and development of castings for airframe structure; specifically, determining the location and size of casting microstructure anomalies, determining the mechanical liability of such anomalies, and understanding the inspectability of such anomalies.

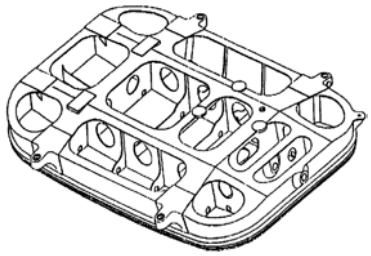
The first issue is addressed by modeling/simulation of foundry processes to assist with predicting the size and location of potential void related anomalies in the cast structure during the earliest stages of product definition. The foundry simulation modeling was performed on both a global and local scales in an effort to achieve some marriage between pore/void formation models and grain nucleation and growth models. Preliminary grain growth and void prediction models were verified by microstuctural analysis of controlled casting experiments using alloy D357.

This effort was complemented by research to develop simulation tools that assist with the simulation of crack growth. A number of meshing and numerical methods were developed that significantly decrease the complexity of the crack analysis problems. These methods were compared with analytical solutions and applied to a number of hypothetical cracks forming in castings.

A third, related research effort (separate task) undertaken at the IAState CNDE by Prof. Joe Gray involved the simulation of x-ray inspection (XRSIM) typically used to find anomalies in castings.

With tools for accurately modeling the location of anomalies in castings, simulation tools for how cracks emanating from these anomalies will impact both static and dynamic mechanical properties, and models for addressing coverage and inspection requirements to reliably detect defects with identified mechanical liability, an integrated system can perform preliminary damage tolerant design.

The simulation tools developed during this program were applied to a structural casting with known mechanical reliability in service, specifically the BOEING 757 EE access door. Results of this analysis will be presented in the presentation including preliminary foundry simulation to identify potential anomalies, static and dynamic strength analysis by advanced meshing methods, and inspection simulation of the identified, critical defects. Challenges addressed in the program together with future research opportunities will be reviewed



Boeing 757 Cast door w/ integral skin